Preface: In order to ease the reporting requirement on myself and my staff, I have divided my MODIS work into a number of "Projects," in which a project is a research objective with associated tasks for which one person has lead responsibility. The projects are described in a two-page write up which summarizes them in a common format.

Each month, the project summary is revised as appropriate, and information on tasks accomplished during the reporting period is provided. I review each project summary to ensure that it is correct and proper.

To fulfill my reporting requirement, I attach the following project summaries with accomplishments during the quarterly reporting period.

EOS-BRDF

1. TITLE: Retrieval of BRDFs and Related Physical Parameters Using EOS Instruments I: Evaluation of Orbit-Sensor Scenarios

2. PERSONNEL: Lead: Alan Strahler. Help: Xiaowen Li, Mike Barnsley, David Jupp.

3. PROJECT AFFILIATION: MODIS

4. DATE PREPARED/UPDATED: 92-4-6

5. BRIEF DESCRIPTION: The abilities of Landsat, AVHRR, SPOT, MODIS-N, MODIS-T and MISR to make directional reflectance measurements are compared and evaluated in the context of deriving BRDFs and structural parameters remotely.

6. BROAD CONTEXT:

    A. Better understand BRDF inference from EOS instruments

    B. Build productive links with international collaborators

    C. Provide context for MODIS BRDF algorithm development

7. REQUIREMENTS:

A. Orbit/angle codes: Mike Barnsley, Xiaowen Li

        B. BRDF models: Xiaowen Li

8. GENERAL PLAN:

        A. Run programs and prepare graphics for typical sensing
        scenarios and proper orbits.

        B. Discuss and compare the abilities of the instruments
to   sample and retrieve the BRDF.

        C. Interpret the implications for EOS, MODIS, and MISR

9. PROJECT STATUS: A. and B., largely complete; C. in
progress

10. PRESENTATIONS/PUBLICATIONS:

        A. Barnsley, Strahler, Muller, Li paper, now in draft.
        To be completed Spring, 1992

        B. Prepare a brief report for the MODIS Team Meeting,
April,   1992.

11. SPECIAL PROBLEMS/COMMENTS: None at this time.

12. REPORTING PERIOD: January-March, 1992

13. ACCOMPLISHMENTS:

        A. Due to the change in EOS configuration to AM and PM
        platforms and the deselection of MODIS-T in favor of
MISR, most   of the calculations carried out for the paper
needed to be   redone. These were the primary activity of
Mike Barnsley at   UCL during the reporting period.

        B. While the calculations were being redone, Alan
revised parts   of the manuscript accordingly, adding to the
discussion, etc.,   to incorporate the program and instrument
changes.

        C. Presently, the manscript is still with Mike Barnsley
and   Peter Muller.

LAND COVER

1. TITLE: Development of Land Cover/Land-Cover Change
Characterization Techniques for MODIS-N: Phase I.

2. PERSONNEL: Lead: Aaron Moody Help: Alan Strahler

3. PROJECT AFFILIATION: MODIS

4. DATE PREPARED/UPDATED: 92-4-5

5. BRIEF DESCRIPTION: The utility of composited AVHRR data for Land Cover/Land-Cover Change categorization is examined in two ways. First, AVHRR characteristics and their relation to broad vegetation cover types are explored for selected ecoregions of the U.S., including New England and Eastern New York, Maryland and the middle Atlantic region, and Southern California. Initial problems include multitemporal registration/rectification, view- and sun-angle dependence, and the role of cloud cover in the compositing procedure. Second, land cover types and characteristics as inferred from AVHRR are examined for a set of 100x100 km. U.S. test areas, including eastern Massachusetts; Konza Prairie; Glacier National Park; La Jornada, New Mexico; and Oak Ridge, Tennessee. Methods of AVHRR processing include unsupervised and supervised classification; clustering based on temporal bands, principal components, and derived variables; labeling of AVHRR-pixels based on NDVI time trajectories; and comparison with MSS and other available data, such as TM and SPOT, for validation. Terrain effects are assessed using digital terrain models.

6. BROAD CONTEXT:

    A. Examine and understand the influence of temporal and spatial   sampling considerations, clouds, compositing, and vegetation   indices on land cover characterization and how these will   affect land cover characterization from MODIS.

    B. Gain a basic physical understanding of the land surface, how   it is changing, and how underlying controlling factors in the landscape influence the land cover.

    C. Develop appropriate procedures for processing AVHRR and, ultimately MODIS data to produce global land cover/land-cover   change inventories.

    D. Provide a Ph. D. for Aaron Moody.

7. REQUIREMENTS:

    A. High temporal resolution AVHRR LAC data at continental and,   eventually global scale.

    B. MSS, TM, SPOT, and ground data from 20 to 30 100x100 km test   sites representing a wide array of land cover types and mixtures.

    C. Global digital terrain data.

8. GENERAL PLAN:

    A. Review the literature for current procedures and
problems associated with processing AVHRR data for land
cover studies. i. e. monitoring vegetation dynamics,
characterizing land cover, limitations of max-value
compositing procedure.

    B. Use AVHRR data to run multiple land cover
classifications using different techniques; eg. supervised
and unsupervised classifications using temporal bands;
principal component bands; and derived variables such as
onset of greenness, max NDVI value, date of max value, length
of growing season, etc.

    C. Collect/compile high resolution satellite data and
field data for a wide range of test sites representing many
land cover types and combinations.

    D. Test, validate and improve the classification
procedures through comparison with the field data and high
resolution satellite data.

    E. Assess relative performance of various classification
    procedures and begin to formulate plan for global land
cover assessment.

    F. Examine relationships between non-land cover related
factors and the quality of the composited data.

9. PROJECT STATUS: A-C, F, in progress; D, E, begin Fall,
1992.

10. PRESENTATIONS/PUBLICATIONS:

    A. Article on clouds and viewing angle problems in
composited AVHRR data; submit Spring 1992.

    B. Articles comparing performance of various
classification techniques across a host of test sites; submit
Fall 1993.

    C. Moody Ph.D. dissertation.

11. SPECIAL PROBLEMS/COMMENTS: No problems/comments

12. REPORTING PERIOD: January-March, 1992.

13. ACCOMPLISHMENTS:

    A. Review of global/regional land cover studies using
AVHRR data. Focused on four main themes: issues involved in
maximum value compositing procedure; monitoring of vegetation

dynamics; vegetation classification; and issues of spatial and temporal resolution. Began write up of literature review.

B. Contacted Alfredo Huete. Requested archived Landsat MSS scenes for Glacier National Park, Montana; La Jornada, New Mexico; Harvard Forest, Massachusetts; Konza Prairie, Kansas; Oak Ridge National Lab, Tennessee. All except ORNL site are in the process of being requested from EROS Data Center by Alfredo Huete. Also contact Steve Running about sharing more detailed data (i. e. MSS, TM, SPOT, and land cover maps) for the Glacier National Park site. Preliminary Harvard Forest data is on   line.

C. Examined relationships between AVHRR composited NDVI values (biweekly) and solar zenith angle and relative azimuth angle. There does not initially appear to be any relationships between these factors.

D. First and second drafts of paper (A) completed. Focus on: influence of viewing angle on data quality; success of compositing procedure in eliminating cloud contaminated and off-nadir pixels; influence of data receiving station on view angle of imagery. Next draft in progress.

E. Preparation of presentation of research results for MODIS meeting.

MODIS-SPATIAL STRUCTURE

1. TITLE: Development of Measures of Spatial Structure in MODIS-N 250m Imagery and Their Application for Local Surface Characterization and Subpixel Cloud Detection.

2. PERSONNEL: Lead: Pamela Cashman. Help: Shunlin Liang

3. PROJECT AFFILIATION: MODIS

4. DATE PREPARED/UPDATED: 92-4-3

5. BRIEF DESCRIPTION: Measures of spatial structure and their information content are explored for 250-m and 1-km MODIS imagery which has been simulated by collapsing Landsat TM bands 3 and 4 to a lower resolution using an IFOV-simulating Fourier convolution filter. Measures tested include window variance and cross-band correlation; adjacent pixel variance and cross-correlation; and one-dimensional semivariance and co-semivariance. The measures are examined for their ability to (1) characterize the spatial pattern of land surface covers, and (2) detect the presence of cloud cover for flagging of 1-km MODIS pixels.

6. BROAD CONTEXT:

A. Understand better the spatial characteristics of land covers at multiple resolutions.

B. Identify candidate algorithms for use in MODIS-N processing.

C. Enhance our ability to process images for spatial information by developing appropriate software.

D. Provide an MA degree for Pamela Cashman.

7. REQUIREMENTS:

A. Simulated two-band MODIS-N data at 250m and 1km resolutions.

B. Programs to calculate spatial structure measures in non-moving image windows.

8. GENERAL PLAN:

A. Search literature for relevent papers.

B. Acquire simulated MODIS-N data for clear and partly cloudy scenes from John Barker, GSFC.

C. Calculate variograms and simple statistical measures (such as mean and standard deviation) for 16 pixel groups (corresponding to 1 1-km pixel) for each 250-m band.

D. Compare variograms to spectral reflectance distributions (in 4x4 windows), searching for patterns and irregularities.

E. Calculate cross-correlation measures between the 250-m bands.

F. Calculate other measures of spatial structure such as texture and spatial frequency (Fourier transforms) for both 250-m bands in 4 x 4 windows.

G. Examine spatial heterogeneity as a function of the landscape, and examine how spatial measures are influenced by partial cloud cover.

H. Quantify cloud cover for each 1-km pixel based on 250-m data.

I. Develop a procedure (complete with appropriate algorithm(s)) and indexing system to quantify spatial structure and variation.

J. Test the procedure on both atmospherically corrected and uncorrected data to determine the importance of when to apply the algorithm(s).

K. Prepare Thesis/publication manuscript.

9. PROJECT STATUS: A. largely complete; B complete for cloud-free images; C, D, and E in progress.

10. PRESENTATION/PUBLICATIONS:

A. Article in appropriate journal.

B. Cashman MA thesis.

11. SPECIAL PROBLEMS/COMMENTS:

A. Examination of the original TM data has revealed few cloudy pixels.

12. REPORTING PERIOD: January-March, 1992.

13. ACCOMPLISHMENTS:

A. Received Chernobyl data from J. Barker & Co. at GSFC. Archived into IPW format, displayed and examined data.

B. With help of Shunlin, wrote program to calculate variogram and related statistics for the 16 250-m pixels in each 1-km pixel.

C. Plotted variograms and compared with imagery to understand spatial patterns and how they are reflected in the variogram values.

D. Began preparation of viewgraphs for Alan to present at MODIS Team meeting.

STAT-BRDF

1. TITLE: A Statistical BRDF Model

2. PERSONNEL: Lead: Shunlin Liang. Help: Abuelgadir Elgasim.

3. PROJECT AFFILIATION: MODIS

4. DATE PREPARED/UPDATED: 92-04-02

5. BRIEF DESCRIPTION: We develop a simple but effective method for characterizing and retrieving the BRDF from directional measurements at the top of the atmosphere. The

BRDF is modeled as a composite of two functions--a limacon function that produces the familiar bowl-shape of BRDF's, and a hotspot function, using an exponential Hapke-type kernel. Using six parameters, the LARS soybean BRDF data of Ranson et al. is fitted within 3%. Inversion is tested with ASAS data from the FEDMAC experiment for the infrared band to retrieve BRDF shape. Further, the model can be easily incorporated into atmospheric models as a nonlambertian boundary condition.

6. BROAD CONTEXT:

    A. Enhance our understanding of the characteristics of BRDFs.

    B. Explore BRDF retrieval in the context of MODIS/MISR EOS instruments.

    C. Ph.D for Shunlin Liang.

7. REQUIREMENTS:

    A. Ranson soybean reflectance data.

    B. ASAS data for OTTER site (Irons) and PARABOLA BRDF measurements (Deering).

    C. Running C programs for BRDF retrieval.

8. GENERAL PLAN:

    A. Develop the statistical BRDF model.

    B. Develop parametric atmosphere RT model over nonlambertian surface model.

    C. Validate with Ranson soybean canopy reflectance measurements.

    D. Obtain ASAS data from OTTER experiment.

    E. Retrieve BRDF from ASAS, compare fit with measurements and possibly Li-Strahler G-O BRDFs. Use OTTER sun photometer measurements for atmospheric parameters.

    F. Retrieve BRDF from PARABOLA measurements by Deering of shinnery oak.

    G. Prepare dissertation/publication manuscript.

9. PROJECT STATUS: A.-F. complete; G. in progress.

10. PRESENTATIONS/PUBLICATIONS:

A. Retrieval of BRDF from multiangle remotely sensed
data, for Remote Sensing of Environment, May, 1992.

    B. Ph.D dissertation, May, 1992.

11. SPECIAL PROBLEMS/COMMENTS: No special problems.

12. REPORTING PERIOD: January-March, 1992

13. ACCOMPLISHMENTS:

    A. Continued development of BRDF characterization.
Compared hotspot model using 2-D multivariate normal shape
to simple negative exponential Hapke-type model, and selected
Hapke as the better fit.

    B. Ran and tested model against discrete ordinates
solution for coupled atmosphere-canopy BRDF and obtained
good fit as long as view angles are not greater than about 40
degrees.

    C. Used method to retrieve BRDF from OTTER ASAS
measurements and Deering's shinnery oak data, got good fits.

    D. Developed first and second drafts of manuscript for
RSE submission.

BRDF ALBEDO

1. TITLE: Modeling the Direct-Beam Instantaneous Spectral
Surface Albedo of a Forested Landscape using Geometic-Optics
and a Distributed Parameter Approach

2. PERSONNEL: Lead: Crystal Schaaf Help: Xiaowen Li, Shunlin
Liang

3. PROJECT AFFILIATION: MODIS

4. DATE PREPARED/UPDATED: 92-4-3

5. BRIEF DESCRIPTION: The Li-Strahler geometric-optical model
represents the BRDF of an anisotropic canopied surface. This
model can be extended by integrating over all view angles to
provide a direct-beam, instantaneous surface albedo for that
surface. Further integration over the sun's path in the sky
can yield daily or longer interval albedos as well. These
spectrally dependent hemispherical reflectance values do not
directly include multiple scattering, diffuse or specular
effects, although some accomodations for these phenomena can
be made. The sensitivity of modeled albedos to illumination
angle, topography, and sensor resolution will be explored in

the context of parameterizing climatic models for rugged
terrain.

6. BROAD CONTEXT:

        A. Extend the Li-Strahler model to calculate
instantaneous spectral albedos and ultimately to produce the
daily albedos used by the climate modeling community.

        B. Come to an understanding of how albedos vary within
and across the landscape.

        C. Simulate the albedo computations that will be
possible with EOS sensors such as MISR.

        D. PhD for Crystal Schaaf.

7. REQUIREMENTS:

        A. Albedo code from Li-Strahler mutual shadowing model.

        B. Code to compensate for the effect of topography.

        C. Scene simulation system.

8. GENERAL PLAN

        A. Implement albedo calculations.

        B. Test sensitivity of calculation to solar illumination
angle.

        C. Create a simulation scene to test topographic and
scene versus pixel sensitivities.

        D. Implement topographic corrections.

        E. Test sensitivity of modeled albedo to topography and
compare pixel albedo to scene albedo.

        F. Prepare dissertation/publication.

9. PROJECT STATUS: A and B complete, C in progress.

10. PRESENTATIONS/PUBLICATIONS:

        A. Poster for IGARSS conference -- May 92.

        B. Journal article for IEEE special issue -- due 1 Sept
92

        B. PhD Dissertation or journal articles.

11. SPECIAL PROBLEMS/COMMENTS: No problems.

12. REPORTING PERIOD: January-March 1992

13. ACCOMPLISHMENTS:

    A. The primary activity during this reporting period has been revising, rewriting and debugging the Li-Strahler mutual shadowing model for computation of the BRDF. The earlier version of this code incorporated a sensor model for generating view and sun angles, which limited its usefulness. Further, Dr. Li has continued to improve the model even as it was being recoded.

    B. Many model runs were carried out for the OTTER sites, facilitating the comparison of the Li-Strahler mutual shadowing BRDF with ASAS measurements. This work was used by Elgasim for his paper.

    C. A real conifer forest scene was obtained from the Forest Service project along with structural parameters that will allow distributed parameter BRDF modeling. Code is under development to model spectral albedo given appropriate component signatures.